Biological Molecules - Proteins

1. Which of the rows, **A** to **D**, correctly describes the properties of the named proteins?

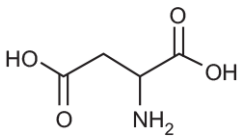
Row	Collagen	Insulin	Elastin	Haemoglobin
A	fibrous protein which is flexible but does not stretch	globular protein with specific, fixed shape	fibrous protein which recoils after being deformed	globular protein which cannot change shape
B	fibrous protein which is flexible but does not stretch	globular protein with specific, fixed shape	fibrous protein which recoils after being deformed	globular protein which can change shape
C	fibrous protein which recoils after being deformed	globular protein with specific, fixed shape	fibrous protein which is flexible but does not stretch	globular protein which can change shape
D	fibrous protein which is flexible but does not stretch	globular protein which can change shape	fibrous protein which recoils after being deformed	globular protein with specific, fixed shape

Your answer ☐

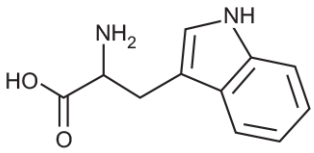
[1]

2. Which of the following could **not** be an amino acid?

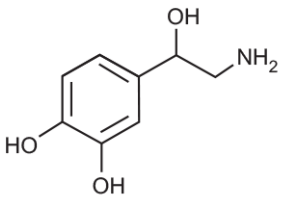
A



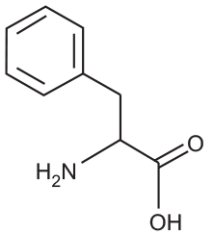
B



C



D



Your answer ☐

[1]

3. The following are a series of organic molecules and the chemical processes that occur to convert them into different molecules.

Which of the rows, **A** to **D**, is correct?

A nucleic acid —hydrolysis→ nucleotide —hydrolysis→ polynucleotide

B α-glucose —condensation→ amylopectin —hydrolysis→ α-glucose

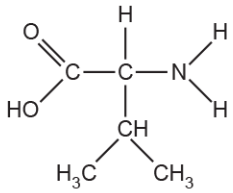
C amino acid —condensation→ dipeptide —hydrolysis→ polypeptide

D β-glucose —condensation→ cellulose —condensation→ maltose

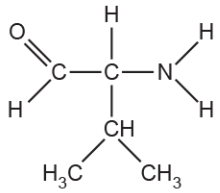
Your answer ☐ **[1]**

4. Which of the following molecules, **A** to **D**, could be a product of breaking a peptide bond during a hydrolysis reaction?

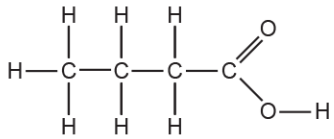
A



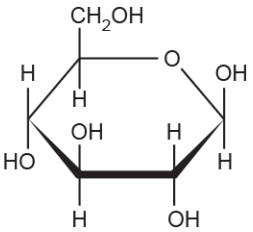
B



C



D



Your answer ☐ **[1]**

5. Which of the rows, **A** to **D**, contains the correct elements that are found in proteins?

	carbon	hydrogen	oxygen	phosphorus	nitrogen	sulphur
A	✓	✓	✓			
B	✓	✓	✓	✓	✓	
C	✓	✓	✓		✓	✓
D	✓	✓	✓	✓	✓	✓

Your answer ☐ **[1]**

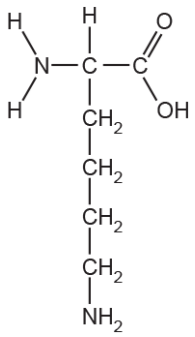
6. A conjugated protein is held together by many different types of bond.

Which bond is **not** formed when a conjugated protein folds into its quaternary structure?

A disulphide
B hydrogen
C ionic
D peptide

Your answer ☐ **[1]**

7. Which of the types of molecule is shown in the diagram?



A amino acid
B fatty acid
C nitrogenous base
D nucleotide

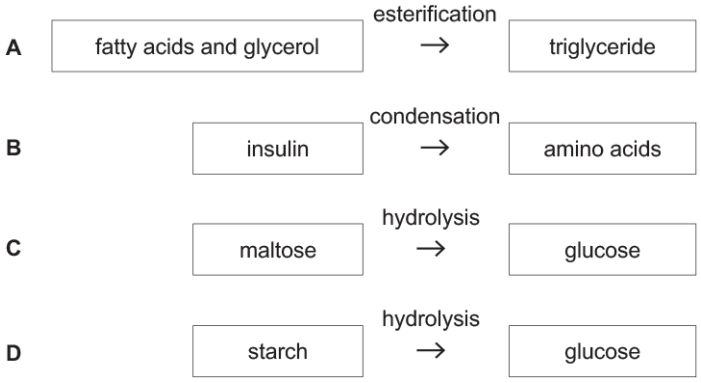
Your answer ☐ **[1]**

8. Which of the options is a function of fibrous proteins?

A aids rigidity of membranes
B involved in cell signalling
C provides elasticity in alveoli
D speeds up reactions

Your answer ☐ **[1]**

9. Which of the following reactions, **A** to **D**, describes the conversion of a polymer to a monomer?



Your answer ☐ **[1]**

10. The table below shows four biological molecules and their component elements.

Which of the rows, **A** to **D**, correctly identifies the elements in each molecule?

	sucrose	**cholesterol**	**insulin**	**ATP**
A	C, H, O	C, H, O, N	C, H, O, N, S	C, H, O, N, P
B	C, H, O, N	C, H, O	C, H, O, N, S	C, H, O, N, S
C	C, H, O	C, H, O	C, H, O, N, S	C, H, O, N, P
D	C, H, O	C, H, O	C, H, O, N, P	C, H, O, N, P

Your answer ☐ **[1]**

11. Fig. 5.1 shows part of a conjugated protein that is a respiratory pigment in muscle cells.

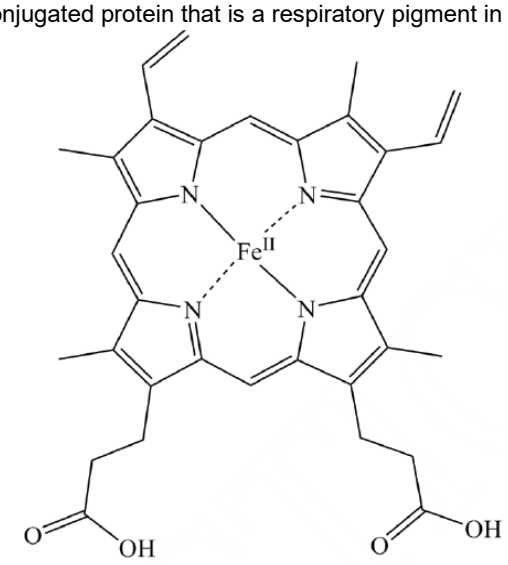


Fig. 5.1

Which part of the molecule does Fig 5.1 represent?

A prosthetic group
B disulfide bond
C quaternary structure
D polypeptide

Your answer ☐

[1]

12. Root vegetables require sulfate ions (SO_4^{2-}) in order to grow to a normal size. The plant uses the sulfur atoms to synthesise biological molecules during growth.

Sulfur atoms are required for the synthesis of which type of biological molecule?

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[1]

13.

Fig. 1.1 shows the general structure of an amino acid.

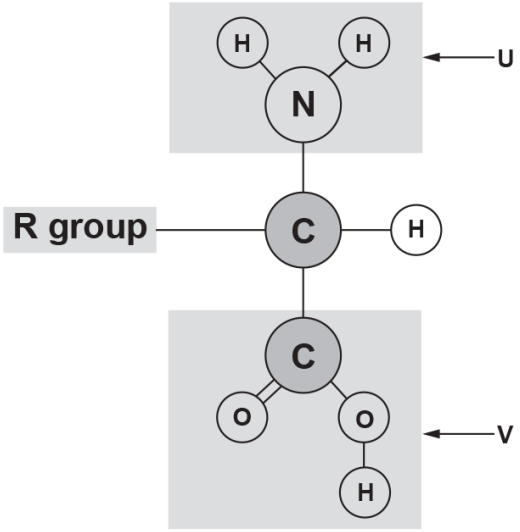

Fig. 1.1

i. State the names of the groups labelled **U** and **V**.

U ----------

V ----------

[1]

ii. Fig. 1.2 shows a representation of a short polypeptide chain made from three amino acids.

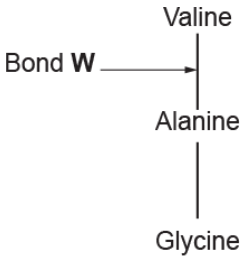

Fig. 1.2

Name bond **W and** state what type of reaction takes place to form this bond.

Name of bond **W** ----------

Type of reaction ----------

[2]

14. Rubredoxin is a protein found in bacteria. It contains around 50 amino acids. One iron ion is bound by the sulphur atoms of four cysteine amino acids.

The structure of rubredoxin is shown in Fig. 20.1.

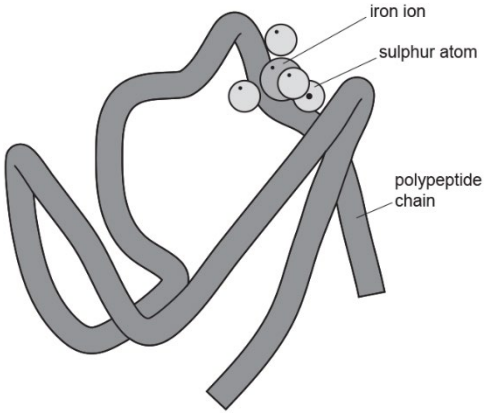

Fig. 20.1

i. Rubredoxin is known as a **conjugated protein**.

Use Fig. 20.1 to explain what is meant by the term conjugated protein.

---

[3]

ii. Using the information provided about rubredoxin, state **two** similarities between the structures of rubredoxin and haemoglobin.

similarity 1

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similarity 2

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[2]

iii. Rubredoxin and haemoglobin have different secondary and tertiary structures.

Using the information provided about rubredoxin, state **two other** differences between the structures of rubredoxin and haemoglobin.

difference 1

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difference 2

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[2]

15(a). * Describe how the structure of llama haemoglobin is likely to be different from that of camel haemoglobin with reference to the four levels of protein structure.

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_____

_____

_____

[6]

(b). Haemoglobin is a protein that carries oxygen in the blood of all mammals. The structure of haemoglobin can vary slightly between species.

Fig. 4.1 shows a llama, a relative of the camel.

Fig. 4.1

- Llamas live at high altitudes and camels live at low altitudes.
- At high altitudes the partial pressure of oxygen is low.
- Llama and camel haemoglobin consists of 2 α subunits and 2 β subunits.
- Each subunit contains a haem group and is able to bind to one molecule of oxygen.
- In the β subunits, one amino acid present in camel haemoglobin has been replaced by a different amino acid in llama haemoglobin.

Fig. 4.2 shows dissociation curves for llama haemoglobin and camel haemoglobin.

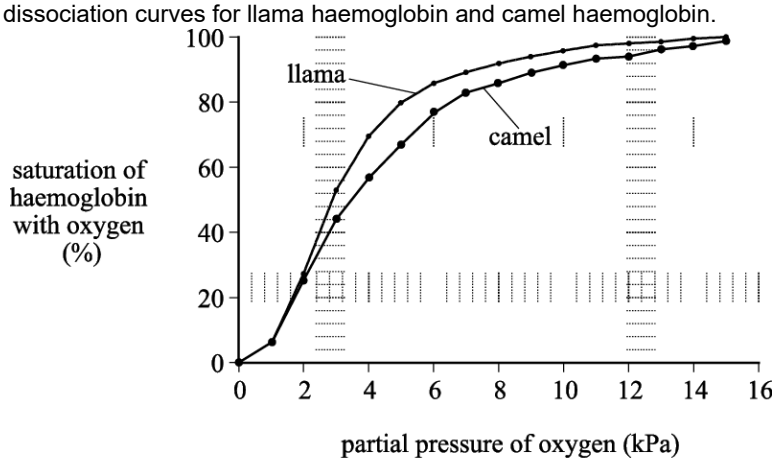

Fig. 4.2

i. State the partial pressure of oxygen that results in a saturation of 50% in llama haemoglobin.

Answer……

[1]

ii. Explain why it is important for the survival of the llama that the llama haemoglobin dissociation curve is to the left of the camel haemoglobin dissociation curve.

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[2]

(c). Collagen is a fibrous protein.
State three **properties** of a fibrous protein that are different from those of a globular protein.

1

2

3

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[3]

16. Bread contains a mixture of polypeptides known as gluten.

Gluten consists of two types of polypeptide: gliadins and glutenins.

i. The table below contains statements about the structures of gluten polypeptides.

In the boxes next to each statement, write the level of protein structure (primary, secondary, tertiary, or quaternary) to which the statement refers.

Statement	Level of protein structure
Short α-helical sections are present in both polypeptides because of their high proline content	
Intermolecular bonds form between glutenin and gliadin polypeptides	
Up to 45% of the amino acids in gliadins are glutamine	
Hydrophobic amino acids such as glutamine and proline are not found on the surface of gluten proteins	

[2]

ii. Coeliac disease is caused by an immune reaction to gliadins in a person's digestive system. The immune system produces antibodies that bind to part of the gliadin polypeptides, which causes inflammation.

Some people who stop eating foods that contain gluten still occasionally experience the symptoms of coeliac disease.

What can you conclude about:

- the structure of the antibody that causes coeliac disease; and
- what the antibody binds to when producing the symptoms of coeliac disease?

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[2]

17.

Pepsin is a protease enzyme with a polypeptide chain containing 327 amino acids.

Titin is the largest known protein. It has a polypeptide chain containing at least 92 times more amino acids than pepsin.

i. DNA sequences in genes code for polypeptide molecules such as pepsin and titin.

Explain why a process known as transcription is necessary for polypeptide synthesis.

_____

_____

_____

_____

[2]

ii. Calculate the minimum length of the DNA base sequence required to code for titin.

Show your working.

Answer .....

[2]

iii. Titin is a fibrous protein. Pepsin is a globular protein.

Compare the properties and functions of fibrous proteins and globular proteins in the human body.

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_____

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[6]

iv. Another protease enzyme is HIV1 protease, which is essential for the life cycle of the human immunodeficiency virus (HIV). Inhibition of this protease prevents HIV from maturing.

In 1995, saquinavir was the first HIV1 protease inhibitor drug to be approved by the US Food and Drug Administration (FDA).

The data in Fig. 1.3 show the number of acquired immune deficiency syndrome (AIDS) diagnoses and deaths between 1981 and 2007 in the US.

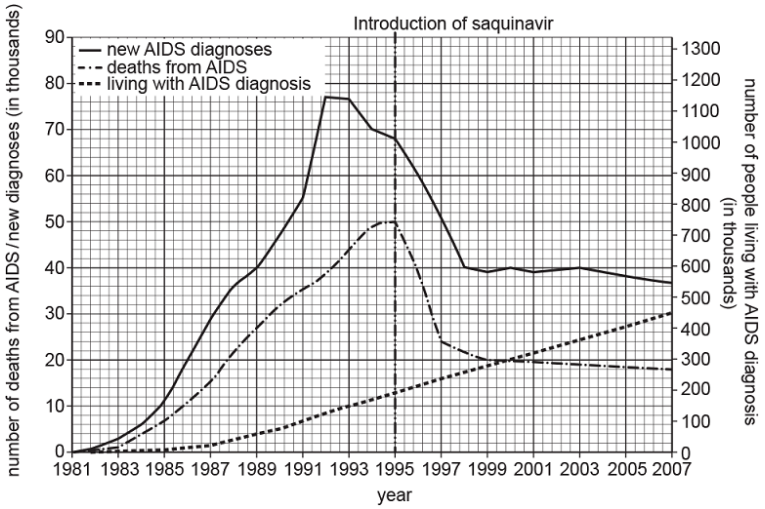


Fig. 1.3

Calculate the rate of decrease in deaths from AIDS between 1995 and 1998.

Give your answer to **two significant figures**

Show your working.

Answer ..... Units .....

[2]

v. A student looking at the data in Fig. 1.3 made the following conclusion:

> "The decrease in deaths from AIDS after 1995 is because of the use of saquinavir by HIV patients."

Suggest why this conclusion may be invalid based on the data in Fig. 1.3.

---

[2]

18. Collagen is a protein found in arterial walls. A collagen molecule has three polypeptide chains, each with 1050 amino acids, wrapped into a triple helix. A repeating sequence of the amino acids glycine and proline occur in each polypeptide chain. These amino acids have non-polar side chains.

i. Describe and explain why collagen is a fibrous protein.

[3]

ii. Suggest why collagen is such a strong molecule.

[1]

19. Ferritin is a protein that is used to regulate iron levels within plant tissues.

It is a large spherical structure which can hold many iron (Fe^{3+}) ions at its centre.

Iron can be toxic to plant tissues. Ferritin prevents the build-up of iron.

Fig. 20.2 shows the internal structure of ferritin.

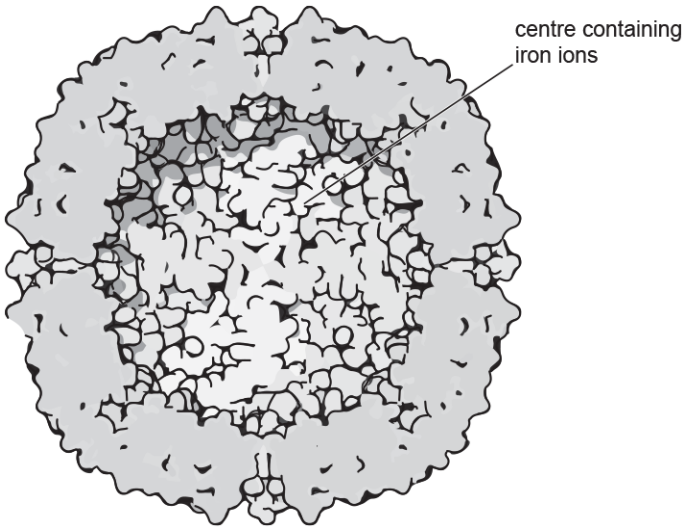


Fig. 20.2

i. Ferritin molecules can hold 4500 Fe^{3+} ions in the inner sphere.

It is thought that the Fe^{3+} ions are unable to occupy the total available volume of the inner sphere because other molecules are present in the inner sphere.

The volume of the inner sphere of the ferritin molecule is 268 nm^3.

The volume of an Fe^{3+} ion is 9.04×10^{-4} nm^3.

Calculate the volume of the inner sphere **not** occupied by Fe^{3+} ions.

volume = ... nm^3

[3]

ii. Explain how hydrophilic and hydrophobic interactions contribute to the spherical shape of ferritin.

---

[1]

20. Fig. 25.1 represents the tertiary structure of the enzyme lysozyme.

Fig. 25.1

i. Name the covalent chemical bond labelled **X** which links two cysteine amino acids.

---

[1]

ii. Name the structure labelled **Y** which forms part of the secondary structure of lysozyme.

---

[1]

iii. Lysozyme consists of a single polypeptide chain of 129 amino acids.

State which level of protein structure is **not** shown by lysozyme.

---

[1]

21. The sweet pea plant has been used to study inheritance since the nineteenth century. The seeds of the sweet pea can vary in colour and shape.
The gene that controls colour has two alleles:

- **Y** is dominant and produces yellow seeds.
- **y** is recessive and produces green seeds.

The gene that controls shape has two alleles:

- **R** is dominant and produces round seeds.
- **r** is recessive and produces wrinkled seeds.

The yellow colour in peas is the result of an enzyme that breaks down chlorophyll, which is green.

- The **Y** allele codes for the production of an enzyme that breaks down chlorophyll.
- The **y** allele is the result of a mutation in the **Y** allele.
- The **y** allele codes for an inactive form of this enzyme.

i.  Outline how the **Y** allele codes for the production of this enzyme and explain why the **y** allele codes for an enzyme with a different primary structure.

[6]

ii. With reference to the proteins coded for by the seed colour gene, explain why the **y** allele is recessive.

_____

_____

[1]

22. Valine, citrulline, hydroxyproline and glutamic acid are amino acids that are normally found in considerable amounts in urine. Following certain diets can result in a change in the amino acids present in the urine of some people.

Plan a method to compare the amino acids present in the urine of a person who has been following one of these diets with that of a person who has not.

_____

_____

_____

_____

_____

[3]

23. The walls of blood vessels contain a polymer called collagen.

Name the type of monomer from which collagen is made and explain how two such monomers are joined together.

Name _____

Joined together by _____

_____

_____

[3]

24. *Heliamphora*, shown in **Fig. 18.1**, is a genus of carnivorous plant. Its leaves are adapted to form water-filled traps for insects. The insects are attracted by nectar, then fall into the traps and drown. The plants digest the insects and absorb the mineral ions produced. This allows *Heliamphora* to survive in soils with low mineral content.

Fig. 18.1

Four pigments, A, B, C and D, were extracted from a *Heliamphora* plant. Thin layer chromatography (TLC) was carried out on the pigments. The results of the TLC are shown in **Fig. 18.3**.

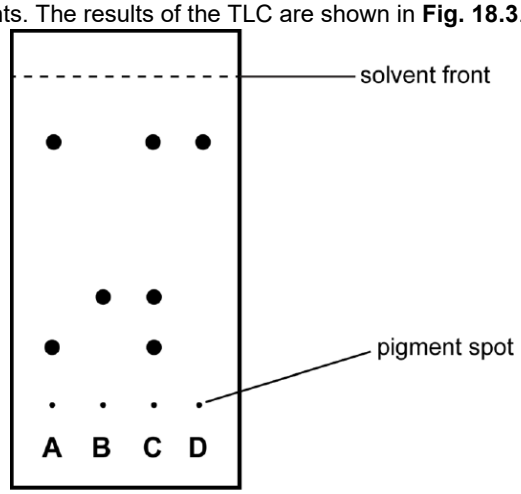


Fig. 18.3

i. Using Fig. 18.3, what can you conclude about the composition of pigments **A** to **D**?

---

[3]

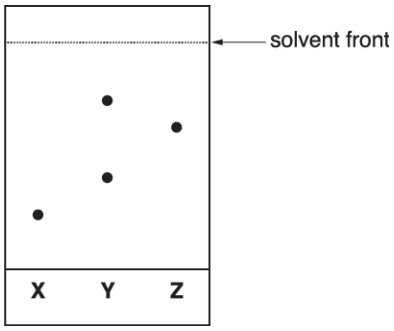
ii. Calculate the Rf value of pigment **B**. Give your answer to **two significant figures**.

Show your working.

Answer = ...

[2]

25. A student investigates some solutions, **X**, **Y** and **Z**, using paper chromatography.
The results are shown below.



Which of the following options, **A** to **D**, is the Rf value of **Z**?

A. 0.63
B. 1.6
C. 0.85
D. 0.25

Your answer ☐

[1]

26.

i. On Fig. 1.1, draw a circle around the R group of leucine.

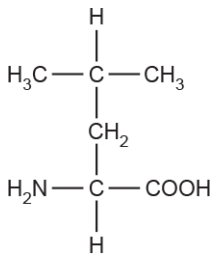


Fig. 1.1

[1]

ii. Students used thin layer chromatography to separate leucine from other amino acids. The chromatogram they produced is shown in Fig. 1.2.

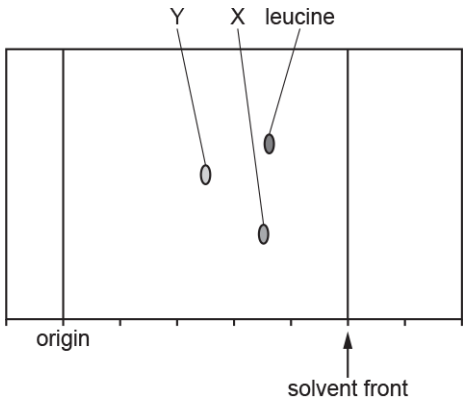


Fig. 1.2

What can you conclude about the chemical properties of leucine and amino acid X?

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[1]

iii. Amino acid Z was in the mixture analysed by the students. It is not shown on the chromatogram in Fig. 1.2. Amino acid Z has an R_f value that is 0.20 lower than that of amino acid Y.

Place a dot on the chromatogram in Fig. 1.2 to show the distance moved by amino acid Z.

Show your working.

[3]

27(a). Collagen is a protein found in arterial walls. A collagen molecule has three polypeptide chains, each with 1050 amino acids, wrapped into a triple helix. A repeating sequence of the amino acids glycine and proline occur in each polypeptide chain. These amino acids have non-polar side chains.

Outline the method of chromatography that will separate the main amino acids in collagen.

_____

_____

_____

_____

_____

_____

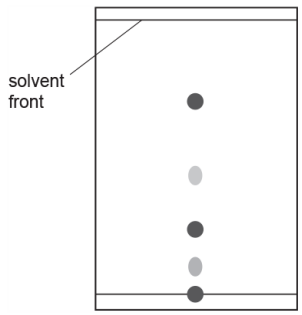
_____

_____

[3]

(b). A student carried out the method of chromatography on a sample labelled 'collagen'. The results can be seen on the chromatogram below.

On a chromatogram, the darker the spot, the higher the concentration of that amino acid.



i. Calculate Rf values for the two highest concentration amino acids.

Rf value 1 = ...

Rf value 2 = ...

[2]

ii. The table shows the Rf values of a range of amino acids.

amino acid	Rf value
glutamine	0.13
glycine	0.27
isoleucine	0.72
leucine	0.73
methionine	0.55
phenylalanine	0.68
proline	0.43
tryptophan	0.66
tyrosine	0.45
valine	0.61

The student thought that they may have made an error and **not** used a sample of collagen.

Use the information in the table to conclude whether the chromatogram shows that the protein analysed is collagen.

Explain your answer.

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[2]

END OF QUESTION PAPER